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(54) ELECTRIC CIRCUIT ASSEMBLIES

(71) We, ELECTROSIL LIMITED, a British company, of Pallion, Sunderland, Co. Durham, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to electric circuit assemblies and is particularly applicable to so-called miniature electric circuit assemblies.

It is known to produce miniature electric circuit assemblies in which one or more resistors are incorporated in a circuit assembly by deposition of resistive material onto an insulating base by a silk screen or vacuum deposition process, such a circuit assembly being generally known as a film microcircuit. It is also known to produce a printed-board miniature electric circuit assembly which includes one or more resistors and/or capacitors mounted above a printed-wiring board. The resistors and/or capacitors are manufactured separately and are of substantially cylindrical, e.g. tubular, form and have electrically-conductive wire or tag terminations attached axially or radially to the cylindrical body to enable electrical connection to be made to the circuit wiring.

According to the present invention there is provided a printed-wiring electric circuit assembly comprising a printed-wiring board and, disposed in at least one hole formed in and extending through the printed-wiring board, a resistor or a capacitor having a substantially cylindrical body with two electrically-conductive terminations each of which is in the form of a band or area extending partially or wholly around one end portion of said substantially cylindrical body, the arrangement being such that the electrically-conductive terminations of said resistor or capacitor are electrically-connected one on each side of the printed-wiring board directly to the printed wiring of the printed-wiring board. By "directly" we mean that no other electrical circuit component is interposed between the terminations and the printed wiring apart from an electrically conductive connection.

Generally, a printed-wiring electric circuit assembly in accordance with the present invention will comprise more than one resistor and/or more than one capacitor disposed in holes formed in and extending through the printed-wiring board.

The resistor(s) and/or capacitor(s) used in the printed-wiring electric circuit assemblies of the present invention are characterised by the lack of need for electrically-conductive wire or tag terminations. It is thus possible, in accordance with the present invention, to produce on a large scale miniature electric circuit assemblies, using discrete resistors and/or capacitors, which are considerably cheaper than equivalent film micro-circuit assemblies produced by the presently known techniques.

Generally, the terminations of the resistor(s) and/or capacitor(s) are connected to the printed wiring of the printed-wiring board by solder, but there can also be used other electrically-conductive substances, e.g. electrically-conductive pastes or resins.

Advantageously, the printed-wiring board used in an electric circuit assembly of the invention comprises a monolithic non-electrically conductive substrate made, for example, from a glass or a ceramic and having a circuit pattern formed thereon. The formation of the holes in the monolithic non-conductive substrate can be effected by chemical etching techniques using, for example, photosensitive glasses and processes such as those described in Britih Specifications Nos 699,897, 699,898 and 752,243. Rectangular or irregularly shaped cylindrical holes can be formed so that, for example, cylindrical resistors and/or capacitors of a non-circular cross-section can be accommodated. The resistors and/or capacitors can also be formed with a monolithic glass or ceramic base, although there can alternatively be used, for example, a composition resistor or a wire-wound resistor.

In another embodiment of the invention, the printed-wiring board used in an electric circuit assembly of the invention is formed from a flexible material, for example resin-bonded paper or glass fibres, which can have a thickness of, for example, about 0.020 inches, and

[Price 25p]

which has the advantage that any differential expansion characteristics can be taken up by the flexibility of the printed-wiring board.

It may also be advantageous in accordance with one embodiment of the invention for the terminations on the resistor(s) and/or capacitor(s) to be electrically-connected directly to the circuit pattern on the printed-wiring board in a manner such that the effective resistive and/or capacitative portion(s) of the resistor(s) and/or capacitor(s), respectively, is or are hermetically sealed.

The printed-wiring board can be prepared using known procedures during or after which one or more holes, as desired, are cut into the board at the appropriate locations. Into the hole or holes there is or are then loaded the resistor(s) and/or capacitor(s) which may be retained temporarily in the hole(s) by mechanical devices. Terminal leads which will be used to connect the completed circuit assembly into a piece of equipment are then attached to the printed-wiring board. A non-corrosive flux is then applied to the board containing the resistor(s) and/or capacitor(s), and the terminations on the resistor(s) and/or capacitor(s) are then electrically connected to the wiring on the board by soldering, for example by dipping into a molten solder bath or by passing through a wave-flow solder bath, or by means of conductive pastes or resins, or by welding. Excess flux is then removed using a solvent, and the printed-board electric circuit assembly air dried. In one such procedure the terminations on the resistor(s) and/or capacitor(s) are initially provided with a fusible, electrically-conductive coating. After the resistor(s) and/or capacitor(s) have been loaded into their holes they are fixed in position by localised application of heat so that the fusible electrically-conductive coating melts and forms a bond between the terminations on the resistor(s) and/or capacitor(s) and the printed wiring. The fusible, electrically-conductive coating can be applied alternatively or additionally to the printed wiring on the board. Alternatively, the printed wiring and/or terminations may themselves, under suitable conditions, be formed from a fusible, electrically-conductive material.

The printed-wiring electric circuit assembly can be encapsulated, in a conventional manner, in a plastics material, e.g. polystyrene, silicone rubber or an epoxy resin, to provide protection from atmospheric conditions, abrasion etc.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:—

Figure 1 shows a side end view of a resistor of heretofore known construction;

Figure 2 shows a side and end view of a resistor as used in a printed-board electric circuit assembly of the present invention;

Figures 3 (a, b and c) show diagrammatically three stages in a method of producing an embodiment of a miniature printed-wiring electric circuit assembly of the present invention;

Figure 4 shows a modification of the embodiment shown in Figures 3 (a to c); and

Figure 5 shows diagrammatically on an enlarged scale part of a second embodiment of a miniature printed-wiring electric circuit assembly of the present invention.

A typical resistor of the heretofore known construction is shown in Figure 1 of the accompanying drawings; and it can be seen that the resistor consists of a resistive portion (1) disposed between and connected to two wire terminations (2) and (3).

A resistor for use in the present invention is shown in Figure 2 and consists of a circularly cylindrical body having a diameter of, for example, about 0.04 inches and comprising a resistive portion (4) and two terminations (5) and (6) each of which is in the form of a band of solderable electrically-conductive material extending around the whole of one end of the tubular body and formed without terminal leads. The resistor can consist, for example, of a short glass tube, as shown in Figure 2, or of a rod, which has been coated with a metal oxide film, for example as disclosed in U.S. Specification No. 2,564,677, to form the resistive portion and on each end of which there has been deposited a band of electrically-conductive paint, e.g. silver paint.

Turning now to Figures 3a to 3c, there is shown in Figure 3a a plan view of a printed-wiring board (11) made of a high alumina ceramic and formed with 28 holes (12) each 0.045″ in diameter and arranged in four rows of seven holes, with the hole centres on an 0.1″ matrix. An interconnecting circuit pattern is then formed, as shown in plan in Figure 3b, on the upper and lower surfaces of the substrate by, for example, a silk screen printing process. This circuit pattern consists of rings (13) surrounding certain of the holes and interconnecting paths (14) between certain of the rings.

There are then prepared a number of resistors of the type shown in Figure 2 and comprising a cylindrical substrate on which there are formed solderable, electrically-conductive end bands (5) and (6) and a resistive portion (4). The resistors are adjusted to desired values by known techniques, for example by grinding a helix into the coating of metal oxide so as to remove the coating along the path of the helix and thus increase the effective length of the electrical path between the terminations. There are also prepared connecting pieces, which are of the same dimensions as the resistors but made of a solderable, electrically conductive material, and terminal

leads, which are made with one end formed to the same dimensions as the resistors and the other end comprising a termination wire.

These three types of element are then fitted into the printed-wiring board with the terminal leads being fitted only in the outer rows of seven holes. The resulting assembly is then dip or wave soldered to form a solder seal wherever an element emerges from the substrate through a conductive ring (13). An end view of the printed-wiring electric circuit assembly thus formed is shown in Figure 3c. This assembly may then either be encapsulated with an insulating material or may be moulded to form a regular shaped package on the same centres as a standard fourteen lead dual-in-line package.

In other embodiments of the invention, part of the printed-wiring board can be free from holes, and other components can be attached to this portion by using any of the techniques commonly employed for attaching components to thin or thick film circuits.

In still further embodiments of the invention a second printed-wiring board is mounted above a printed-board electric circuit assembly such as that described above on extensions of the connecting pieces and terminal leads. This second printed-wiring board can have either one or more resistors or capacitors mounted in holes or other components mounted either in holes or one the surface of the board. A side view of an example of such an embodiment is shown diagrammatically in Figure 4.

Referring now to Figure 5 there is shown in section part of a glass or ceramic monolithic substrate (21) in which there is formed a hole (22). A cylindrical resistor or capacitor, which comprises a resistive or capacitative portion (4) disposed between electrically-conductive terminations in the form of bands (5) and (6), is disposed in the hole (22). Solder fillets (27) form an electrical connection and a hermetic seal between the terminations (5) and (6), and a circuit pattern (28) on the substrate (21).

WHAT WE CLAIM IS:—

1. A printed-wiring electric circuit assembly comprising a printed-wiring board and, disposed in at least one hole formed in and extending through the printed-wiring board, a resistor or a capacitor having a substantially cylindrical body with two electrically-conductive terminations each of which is in the form of a band or area extending partially or wholly around one end portion of said substantially cylindrical body, the arrangement being such that the electrically-conductive terminations of said resistor or capacitor are electrically-connected one on each side of the printed-wiring board directly to the printed wiring of the printed wiring board.

2. A printed-wiring electric circuit assembly as claimed in claim 1, wherein the printed-wiring board comprises a monolithic non-electrically conductive substrate.

3. A printed-wiring electric circuit assembly according to claim 2, wherein the board is of flexible material.

4. A printed-wiring electric circuit assembly as claimed in claim 1. 2 or 3, wherein the electrically-conductive terminations of the resistor or capacitor are electrically-connected to the printed wiring by solder.

5. A printed-wiring electric circuit assembly according to any one of the preceding claims, wherein the resistor or capacitor has been formed without terminal leads.

6. A printed-wiring electric circuit assembly according to any one of the preceding claims, wherein the resistor is a metal-oxide film resistor.

7. A printed-wiring electric circuit assembly according to any one of the preceding claims, wherein the resistor or capacitor has been fitted in its hole prior to connection to the printed wiring.

8. A printed-wiring electric circuit assembly as claimed in claim 1, substantially as hereinbefore described with reference to, and as shown in, Figures 2 to 5 of the accompanying drawings.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG.1

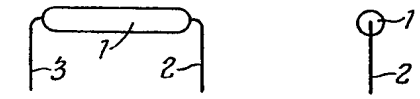
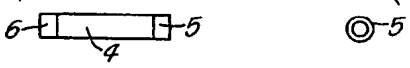
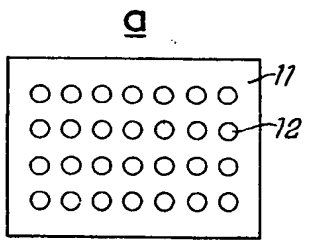
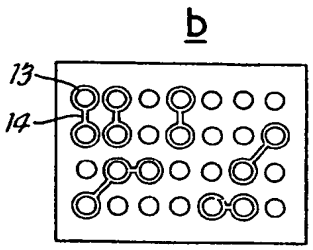


FIG.2







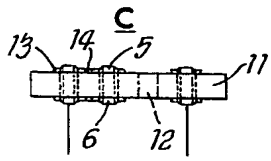


FIG.3

FIG.4

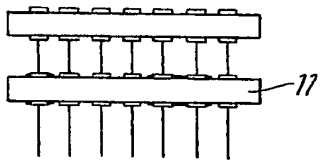


FIG.5